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LED INSTRUMENT APPROACH INSTRUCTION DISPLAY

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LED INSTRUMENT

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16 Abstract A display employing light-emitting diodes (LED'S) has been developed to demonstrate the feasibility of such displays for presenting landing and navigation information to reduce the workload of general aviation pilots during IFR flight. It was constructed with standard, off-the-shelf TTL circuits and LED alpha-numeric displays producing a limited capability prototype used to acquire pilot reaction to such a device under simulated IFR operations. Pilot opinion indicates that the display is helpful in reducing the IFR pilot workload when used with a runway approach plate. However, the development of a second generation display was recommended that would be more compact and consume less power than the prototype, display several instructions simultaneously and would have information update capability. A system built around a microprocessor would fulfill these requirements.					
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LED INSTRUMENT APPROACH

INSTRUCTION DISPLAY

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SUMMARY

A display employing light emitting diodes (LED's) has been developed to demonstrate the feasibility of such displays for presenting landing and navigation information to reduce the workload of general aviation pilots during IFR flight. The display consists of a paper tape reader, digital memory, control electronics, digital latches, and LED alpha-numeric displays. A presetable digital countdown clock-timer is included as part of the system to provide a convenient means of monitoring time intervals for precise flight navigation. The system is a limited capability prototype assembled to test pilot reaction to such a device under simulated IFR operation. Pilot opinion indicates that the display is helpful in reducing the IFR pilots workload when used with an runway approach plate. However, the development of a compact, low power second generation display was recommended which could present several instructions simultaneously and provide information update capability. A microprocessor-based display could fulfill these requirements.

INTRODUCTION

Many general aviation aircraft, including the smaller categories of light aircraft, are now equipped with instrument and navigation equipment that provide relatively inexperienced pilots with the capability for Instrument Flight Rules (IFR) flight. The workload for solo instrument flight, especially in rough air, can be almost beyond the capability of even an experienced pilot. The pilot's workload in solo instrument flight consists of accurate navigation, chart reading, and radio communication with a number of air traffic control facilities, in addition to maintaining precise attitude and trajectory control of the aircraft. In this high workload environment, retrieval of approach information from charts, books, and notes is cumbersome. As a result, light emitting diode (LED) displays are being investigated as a more efficient method of presenting the instruction for landing and approach.

The LED Instrument Approach Instruction Display is a prototype system developed to demonstrate the feasibility of such displays for presenting ILS approach instructions and data. Its purpose was to present sequential information to pilots involved in simulated IFR flight so that their reactions to such displays could be obtained.

This report describes the display operation and electronics and presents a pilot evaluation of the display including suggested modifications and improvements. Information pertaining to the pilot evaluation of the display was provided by Martin T. Moul of the NASA Langley Research Center.

DESCRIPTION OF DISPLAY OPERATION

The LED Instrument Approach Instruction Display (figure 1) presents sequential instructions and data, such as course heading, altitude, and radio frequency, to minimize the pilots workload during instrument flight. A sample of events and data for an ILS approach is presented in figure 2. This type of information is punched in ASC II format onto paper tape which is the input source to the display.

A block diagram of the instruction display is contained in figure 3. Upon command from the Read pushbutton a block of 21 ASC II characters is read from paper tape by the tape reader and stored in the digital memory. The control circuitry reads the memory and distributes the digital data to the appropriate data storage latch. The latches provide a continuous input to the LED display drivers for maximum display brightness. In reality, the use of latches in the system eliminates the need for a digital memory, i.e., the latches serve as a memory. However, both were included in the prototype display to determine what brightness levels could be achieved with and without latching. Also the presence of the digital memory could provide storage of more than one instruction. This allows experimentation with different data input and storage techniques.

Twenty-one commercially available alpha-numeric displays are used in the display section of the instrument. Each display consists of a 5 x 7 LED array covered by a nonreflective, contrast enhancing window and a decoder driver circuit board attached to the LED board. Of the 21 displays, twenty provide information presentation and one indicates the instruction block number, i.e., the number assigned to a particular approach instruction set. A forward/reverse

switch is provided on the front panel of the instrument to reverse the direction of the tape reader and retrieve previous instructions.

A presetable countdown clock-timer has been included along with the instruction display to provide a convenient means of monitoring time intervals for precise flight navigation. A block diagram for the clock-timer is shown in figure 4. The thumb wheel switches preset the counters in the timer circuitry with the desired time interval. Counting is initiated using the COUNT pushbutton switch and the time remaining is displayed on the numeric display of the timer. An alarm can be selected to sound at the end of the time interval.

INSTRUCTION DISPLAY ELECTRONICS

A block diagram for the LED instruction display electronics is shown in figure 5. Each instruction is punched onto paper tape in the form of 23 6-bit ASC II characters (20 instructions or data characters, a block number, a carriage return and line feed) and loaded into the system by the tape reader. The control circuitry consists of 8 flip-flops which operate sequentially to provide command and clock pulses to external circuits and devices. When activated by a read pushbutton switch, the control circuitry sends a pulse to the step motor of the tape reader. The motor advances the paper tape to the first character of the instruction and the reader places this 6-bit character onto the data lines of the digital memory. A write enable command from the control circuitry to memory loads the first character into memory at the location specified by the address counter (00).

Then, the control section increments the address counter, steps the reader motor to input the second character and issues another write enable command to the memory thereby writing the second character into its appropriate memory location (01). This increment - step - write sequence continues until the magnitude comparator (figure 5) encounters an address greater than that of the line feed (23). At this time, the control section receives a pulse from the $A > B$ output of the comparator instructing it to zero the counter and cease stepping the tape reader motor.

The transfer of data from the memory to the display is initiated by a read enable command issued by the control circuitry to the memory. This allows the first character of the instruction to be transferred from memory location 00 to the input lines of 21 digital latches. The address counter output is decoded and used to enable the appropriate latch (0) which holds the data to the input of its corresponding LED display driver. To output the second character to its display, the control circuitry increments the address counter and sends another read enable pulse to the memory. This process continues until all 21 characters have been output to the LED display and the magnitude comparator encounters a line feed. At this time, the comparator instructs the control section to inhibit further activity by the system until it receives another read command from the Read pushbutton switch.

EVALUATION

The LED Instrument Approach Instruction Display has been evaluated for its ability to reduce the workload of general aviation pilots during solo

IFR flight. Simulated test flights were performed in the general aviation aircraft simulator at NASA Langley Research Center using the display to present the landing and navigation information. Pilots with varying degrees of experience were involved in the simulated flight tests and their opinions of the display and recommendations for display improvements were made upon completion of the tests.

The results of the study indicate that the display is helpful to the IFR pilot; however, an approach plate (figure 6) should be retained as part of the system since it provides the pilot with a planview of the airport and runway and a profile view of the approach as well as minimums for alternate approaches. Also, the digital countdown clock (with alarm) was considered to be an improvement over conventional clocks for monitoring time intervals.

The most frequent pilot recommendation involved the size and power consumption of the display. It was necessary to mount the display in the position normally occupied by the right hand passenger seat of the simulator. Miniaturization of the display was suggested to allow it to be relocated on the instrument panel thereby reducing the eye scanning workload of the pilot. Also, a reduction in system power consumption was considered necessary to make the display practical for general aviation aircraft. To further assist the IFR pilot, recommendations were made to present at least three instructions simultaneously and to install the capability to receive update information from air traffic control in a future generation of the display.

DISPLAY IMPROVEMENTS

The LED instruction display is a prototype system which employs standard, off-the-shelf TTL circuits and alpha-numeric displays. Display improvements

such as those suggested by the pilots involved in the simulated flight tests, could be implemented in a second generation display using more sophisticated techniques and state-of-the-art electronics. For instance, a system built around a microprocessor state-of-the-art LED alpha-numeric displays would reduce overall system size and power consumption and increase operational flexibility. When produced in large quantities this display system could be less expensive than the prototype unit; however, such a comparison would depend upon the type of additional features incorporated into the microprocessor based display.

The control, timing and decision making functions performed by electronic hardware in the prototype unit could be implemented in the microprocessor software. The corresponding reduction in system integrated circuit count would significantly reduce the size and power consumption of the display. LED alpha-numeric displays are currently available with four 5 x 7 arrays per package that offer a factor of 5 reduction in size and a factor of 3 less power dissipation (≈ 1.7 watts maximum per array), when compared with the display used in the prototype. When these LED alpha-numerics are employed as the display medium for a microprocessor based display, the resulting compact system becomes practical for mounting on the instrument panel of general aviation aircraft.

The second generation microprocessor display could be designed to present several instructions simultaneously or in a time shared manner. In the simultaneous approach additional displays and output circuits would be required and the processor software would be written to distribute the data to the proper display. The time shared approach would require only one set

of displays and output circuits but more software and memory capacity is required. In this approach, the processor would output an instruction to the display and then enter a delay loop for some predetermined time interval. Upon completion of the delay loop, the processor would output a second instruction and once again enter the loop. This cycle continues for the desired number of instructions until a command from the read pushbutton switch causes the processor to output the next set of instructions. This method would be less expensive to implement than the simultaneous display method since it requires only one set of displays and output circuits.

An instruction display capable of receiving and presenting information from the destination air traffic control center during the approach would further assist the IFR pilot. The information could be continually transmitted from the facility at some assigned frequency. The display electronics would receive, decode and store this information in memory to be recalled and displayed upon command of the pilot. Such a system would provide the pilot with updated information pertaining to his approach as well as the standard approach instructions. Also, the need for loading and inputting data tapes is eliminated. However, the necessity for electronics to receive and decode the instructions and data make the system more expensive to implement than either the prototype display or a microprocessor based display with data tape input.

Several data input methods are more efficient and convenient than the paper tape input source employed by the prototype display. For instance, cassette tapes have data capacities that would allow information pertaining

to the ILS approval of many airports to reside on one cassette. To select a particular approach sequence, the corresponding block number would be input to the system via a thumbwell switch. The decision making capability of the microprocessor software could recognize the selected number, scan the tape and load the desired information into memory for eventual recall. In addition to greater data capacity, cassetts are more convenient to load and more durable than paper tape.

Another data input method involves the most recent development in memory technology, i.e., magnetic bubble memories. These memories are non-volatile, mass storage devices with write as well as read capability. They are presently available in a dual-in-line package less than one-half cubic inch in volume with a data capacity of 92,304 bits. Their compact size makes the bubble memories adaptable to microprocessor systems such as the one suggested as a second generation instruction display. For this application, the bubble memories would be programmed on the ground with IFR approach instructions and data and then inserted into the memory section of the display. Each memory could handle approximately 17 blocks of information about the size of the block shown in figure 2. Therefore, in a microprocessor display which employs bubble memories, the pilot has information pertaining to the approach to many airports residing permanently in memory and no further input device is required.

CONCLUDING REMARKS

The LED Instrument Approach Instruction Display is a prototype system developed to demonstrate the feasibility of such displays for presenting approach instructions and data to the IFR pilot. It was constructed with standard off-the-shelf TTL circuits and LED displays producing a limited capability system used to acquire pilot reaction to such displays under simulated IFR operations. Pilot opinion based on these simulated flights indicate that the display when used with a runway approach plate is helpful in reducing the pilot's workload.

However, more sophisticated techniques and state-of-the-art electronics could be used to develop a second generation display more suited to general aviation aircraft. A microprocessor based display built as a second generation system would fulfill requirements for lower power dissipation and reduced size. Large scale production of such a display could reduce the cost to below that of the prototype unit. The microprocessor based display capability could be expanded to include the presentation of more than one instruction simultaneously and an information update feature. These features would result in an increase in system hardware, software and overall cost. However, additional research is required to accurately evaluate system cost and benefit as functions of capability.

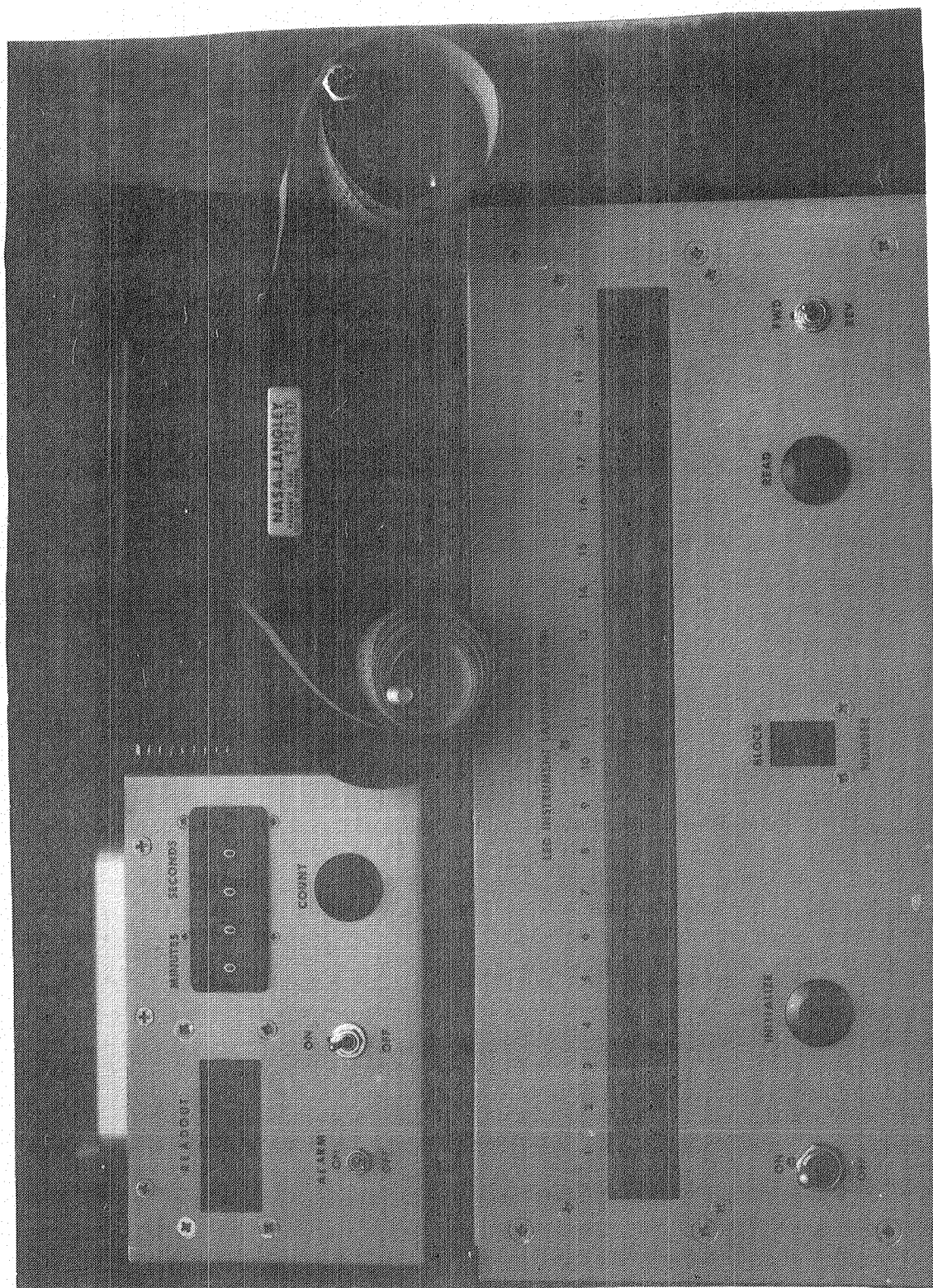


Figure 1.- Photograph of the LED Instrument Approach Instruction Display.

Col. 1

PORTLAND INTERNATL
 ATIS 126.9
 APP CON 118.1
 TOWER 118.7
 ILS RWY 10R
 DIRECT APPROACH
 PROCEDURE TURN
 MINIMUM ALT 3400 FT
 COURSE 222 DEG
 ADF ON ANT 332 FREQ
 IDENTIFY SVY
 ***, ***, -, -*-
 ADF ON ADF
 TRACK SAUVIES ISLAND
 SET TIME 1 MIN
 CHECK MARKER BEACON
 MARKER AUDIO
 SET 109.9 NAV 1
 IDENTIFY IPDX
 , *--*, -, -*-
 SET 278 OBS 1
 90 KNOTS IAS
 FUEL PUMP ON
 FUEL TO FULL TANK
 MIXTURE RICH
 OVER FIX
 START TIMER
 TURN TO 278 DEG
 REPORT SAUVIES ISLAND
 OUTBOUND
 TIME ALTITUDE
 TRACK LOCALIZER BC
 MINIMUM ALT 3400 FT
 AT ALARM TURN LEFT
 TO 233 DEG
 TIME 1 MIN

Col. 1 Continued

ALARM TURN RIGHT
 TO 53 DEG
 TRACK LOCALIZER IN
 SET 98 OBS 1
 DESCEND TO 3200 FT
 CARB HEAT HOT
 90 KNOTS IAS
 ALTIMETER SETTING
 TOWER 118.7 COM 1
 REPORT FINAL
 SET TIMER TO
 2 MIN 40 SEC
 INTERCEPT GLIDE SLOPE
 AT NDB FIX
 OVER MARKER
 START TIMER
 REPORT OUTER MARKER
 700 FT MIN CIRCLING
 500 FT MIN LOC
 220 FT MIN ILS
 MISSED APPROACH
 CLIMB TO 3400 FT
 ADF ON 383 ANT
 IDENTIFY LAKE LOM
 **, *-
 FLY DIRECT TO NDB
 LAKE HOLDING LEFT
 OVER FIX TIME 1 MIN
 TURN RIGHT TO
 128 DEG
 AT ALARM TURN LEFT
 TO 278 DEG IN
 OVER FIX LEFT TO
 98 DEG OUT
 278 IN 98 OUT LT

Figure 2.- Typical IFR approach sequential instructions and data.

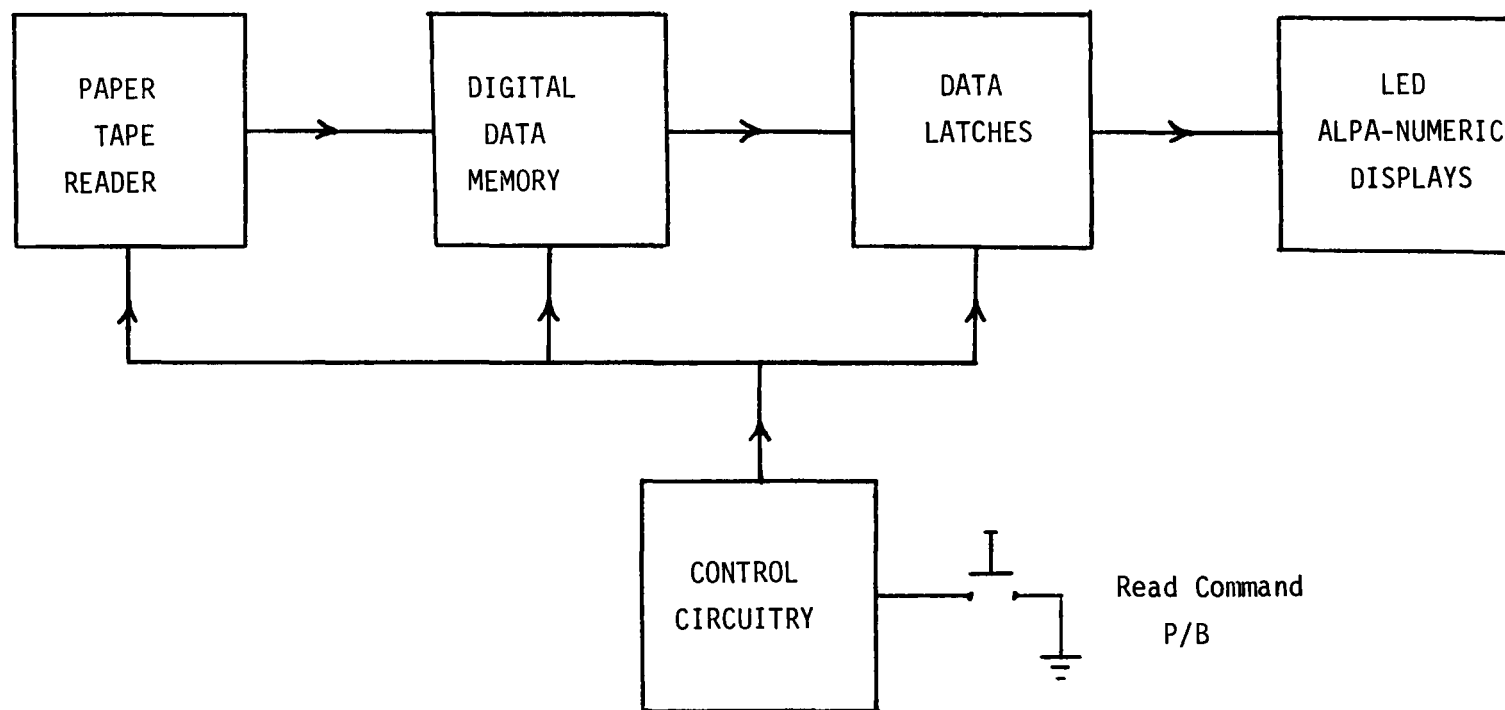


Figure 3.- Block diagram of the instruction display.

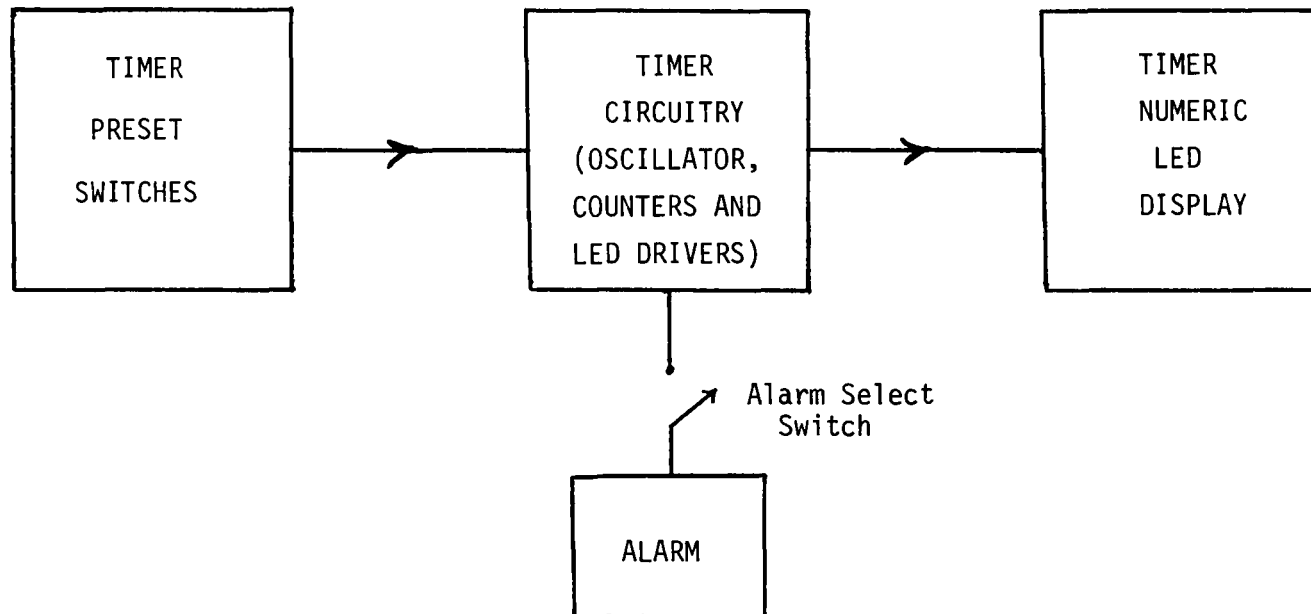


Figure 4.- Block diagram of the clock-timer.

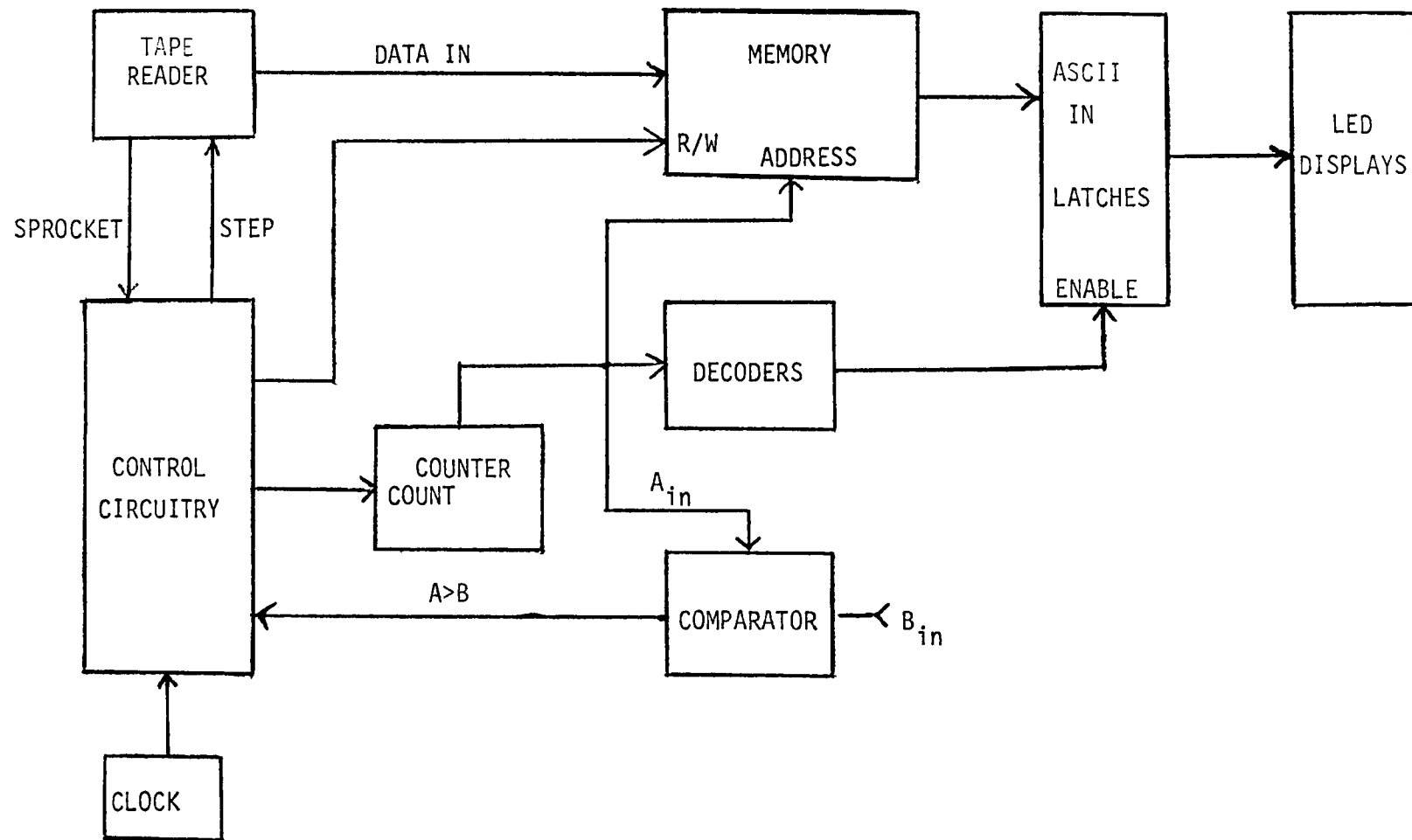


Figure 5.- Block diagram of the instruction display electronics.

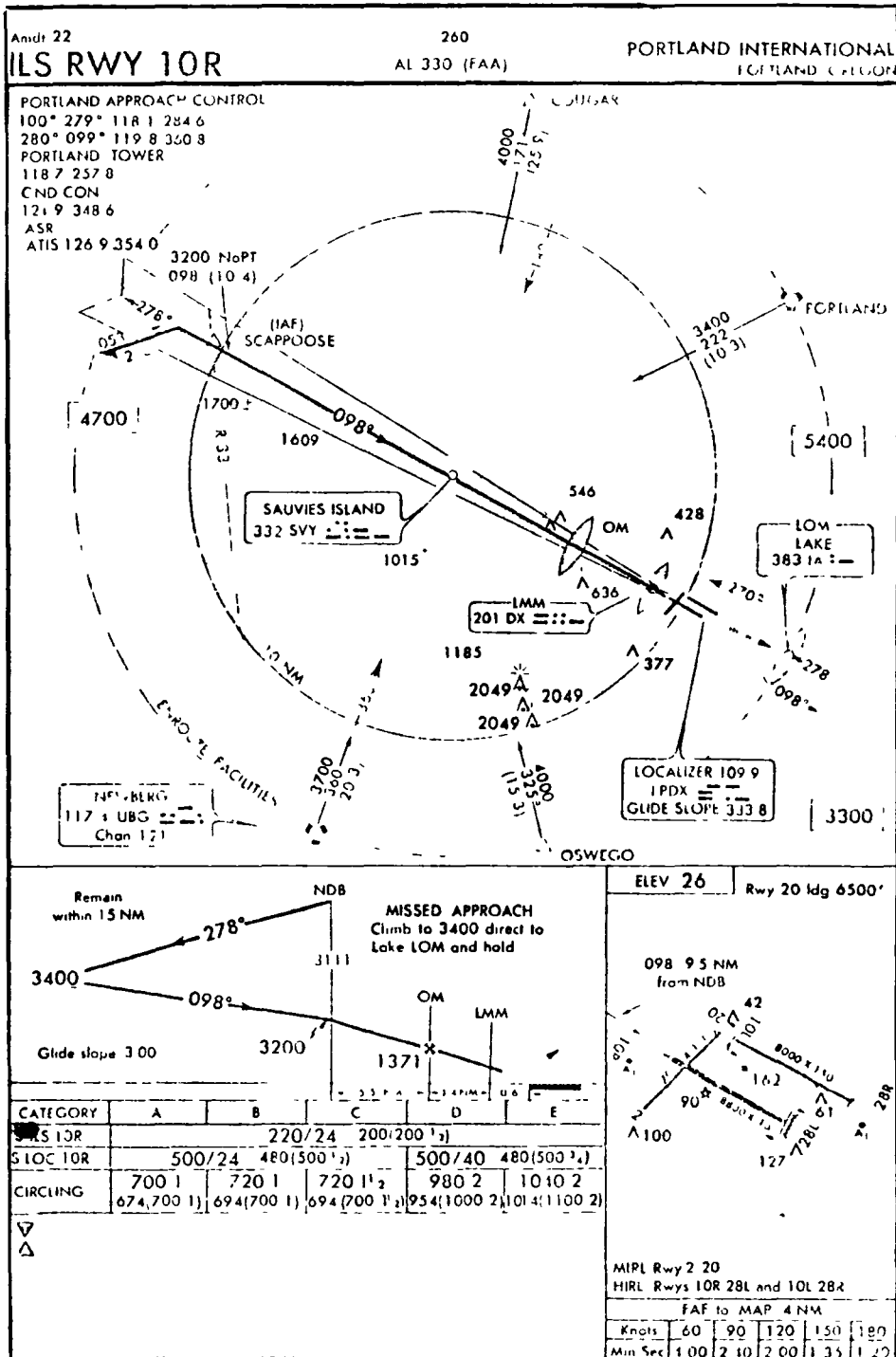


Figure 6.- Typical runway approach plate.

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